National Aeronautics and Space Administration
THEMATIC MAPPER WORKING GROUP PROGRESS REPORT 2

August 1986

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INTERPRETING FOREST AND GRASSLAND BIOME PRODUCTIVITY UTILIZING NESTED SCALES OF IMAGE RESOLUTION AND BIOGEOGRAPHICAL ANALYSIS

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(NASA-CR-179739) INTERPRETING FOREST AND GRASSLAND BIOME PRODUCTIVITY UTILIZING NESTED SCALES OF IMAGE RESOLUTION AND BIOGEOGRAPHICAL ANALYSIS Progress Report (Illinois Natural History Survey, Urbana.) G3/43

N87-12032

Unclas 44541

I. PART 1. INVESTIGATION AND TECHNICAL PLAN

A. SUMMARY

This report summarizes the progress made in our investigation of forest productivity assessment using TM and other biogeographical data during the second six month period of the grant. For appropriate background of study objectives and status after the first six months, reference is made to Report 1.

Several hardware, software, and data collection problems encountered early in the study have been conquered. GIS data from other systems have been converted to ERDAS format for incorporation with the image data. Field collected forest productivity data are available for several study sites. Statistical analysis of the relationship between spectral values and productivity is being pursued. Tasks completed per study area are presented in Table 1.

Given the early setbacks, progress is now being made at a satisfactory rate. Several project sites, including Jackson, Pope, Boulder, Smokies, and Huntington Forest, are evolving as the most intensively studied areas, primarily due to availability of data and time. While other sites will be studied, concentrating our efforts on these fewer areas now promises the most interesting and thoroughly tested results.

B. INTRODUCTION

In this second semi-annual report, we will briefly describe progress made over the past six months. In the interest of time, we will report only the points not described in the first semi-annual report of March, 1986 (hereafter referred to as Report 1). Obviously, much of the work introduced in Report 1 has continued; it will therefore be necessary to refer to Report 1 to get a good picture of progress to date.

The report is divided into two parts: I. Investigation and Technical Plan, and II. Appendices. In Part I, we discuss progress with data acquisition and quality checking, more details on experimental sites, and brief summarizations of research results and future plans. Part II includes appendix material on personnel, collaborators, facilities, site background, and meetings and publications of the investigators.

C. DATA ACQUISITION AND QUALITY CHECKING

1. TM data

Report 1 summarizes the TM data provided by NASA for the study. Additionally, eight Scrounge scenes were sent to cover areas where the TM data quality was poor. These were provided with the understanding that new acquisitions for our project would be discontinued because of excessive costs of EOSAT data.

2. Ancillary Data

a. Illinois GIS Data

The Illinois Geographic Information System has, as part of its database, a 1:40,000 scale integrated terrain unit database for a 44 7.5 minute quad area in southern Illinois. The database was developed for this

area because of its high concentration of surface-minable coal, and the need to derive impact analysis from coal development. The integrated terrain unit mapping includes a large amount of pre-digitizing cartographic effort which allows rectification of several maps. For example, water bodies were digitized off USGS 7.5 minute topographic maps, and the vegetation, soils, and landform maps were matched to the same water body coverage. Similarly, common natural vegetation and soil boundaries were drawn to match each other rather than criss-cross each other to form 'slivers', a severe aggravation in digital GIS processing. The integrated terrain unit includes data on soils, from the Soil Conservation Service national mapping program at the county level (about 3 acre resolution); vegetation including wetlands, as interpreted from 1981-1982 National High Altitiude Program (NHAP) CIR photography; slope, as interpreted from USGS 7.5 minute topographic maps; and landforms, also interpreted from USGS maps.

For the Pope and Jackson study areas, each of the layers has been dissolved out of the integrated terrain unit and soils and vegetation classes have been converted to ERDAS format for processing. There are 30 possible vegetation classes interpreted for forest land, including distinction by height of tree canopy (tall, intermediate, short, shrub), forest type (deciduous, coniferous, mixed), and canopy closure (80-100% cover, 30-80%, and 10-30%). In addition, there are compositional classes associated with the above structure classes, (i.e., mixed hard hardwoods, mixed oak, oak-hickory, cottonwood-willow-sycamore, mixed soft hardwoods, mixed hardwoods, other forest).

The soils classes are coded in by soil mapping unit. For Illinois soils, the soil mapping unit can then be related to numerous other datasets which provide a great deal of information about the soil. Some variables of

interest to us include productivity index for hardwood timber (bd-ft/yr), soil thickness, texture, etc.

b. Elevation Data

Digital elevation data are an important ingredient in our effort to measure relative forest productivity. Such data are being obtained from two principle sources: digital terrain data digitized by the Defense Mapping Agency (DMA) from 1:250,000 scale quadrangles and Digital Elevation Models (DEM) of 1:24,000 scale quadrangles produced by the U.S. Geological Survey. During this reporting period we have worked to 1) obtain the necessary data, 2) obtain or develop programs to read and manipulate the data, and 3) verify the suitability of the resolution and accuracy of the data for our research. To date we have obtained the following data:

* 18 DMA quads covering all of Illinois. The resolution on these data is one second of lat/long (about 63.5 meters).
* 4 DMA quads (portions) covering study areas in Whiteface Mountain, Custer, Sierra National Forest, and Coweeta. These data have a resolution of 2.5 seconds of lat/long (about 158 meters).
* 3 DEM quads covering study areas in Cades Cove, Thunder Head, and Silers Bald, all located in the Smokies.

c. North Central Forest Experiment Station data

The project has benefited by excellent cooperation from the NC Forest Experiment Station personnel, especially Bert Essex and Mark Hanson, from the St. Paul office. The U.S. Forest Service completed a detailed inventory of the State of Illinois in 1985, with a sampling intensity of 121 photo points per township and about six ground plots per township. The ground plot evaluation included several measurements related to forest productivity, including estimates of timber volume, green biomass, and basal area.

We have been given a tape of the entire data set for Illinois. The data for Southern Illinois (which includes Jackson and Pope counties) have been put into the ARC/INFO geographic information system and some preliminary data manipulation has been done. The ground plot location data have been reselected out of the data base and mapped on a UTM based projection of Southern Illinois. These data will be valuable for ground truth in our regression analysis.

d. Other Forest Ground Data

Field collected forest growth data are available for 154 plots in the Smokies. Increment borings were taken that allow for calculation of change in basal area as an estimate of productivity. These plots are restricted to the hardwood zones of the Smokies. It is likely, however, that comparable data will be made available for about 20 spruce-fir plots.

In addition to these data, 18 plots first measured and tagged in 1976-77 throughout the Smokies, by Olson and Beckwith, are planned for remeasurement in the fall of 1986.

D. EXPERIMENTAL SITES AND SURROUNDING (SUB) COUNTIES.

As described in Report 1, 27 sites are being pursued as possible areas for forest productivity analysis (Report 1, Table 3). Of these, major efforts thus far have concentrated on sites in the Smokies, Adirondacks, Jackson, Pope, Calhoun, and Boulder. Ancillary data have been acquired for these sites, including information on soils, vegetation, elevation, and forest productivity. Most other sites also have had ancillary data acquired to some degree (Table 2).

Background material is continually being acquired for all sites. In this report, we provide information concerning the Smokies area (Appendix D).

E. RESEARCH APPROACH AND PRELIMINARY RESULTS

1. Data Handling Progress and Problems.

a. TM Data

As mentioned earlier, Scrounge data were provided by NASA for areas of poor TM data quality. At present, our hardware/software configuration has not allowed the reading of these 6250 bpi Scrounge tapes. Running the ELAS module which reads Scrounge format would require modification to the PRIME operating system. We have temporarily shelved this task until the ERDAS software has been installed on the PRIME (on order).

Our work with areas for which we do have good quality TM data has been made considerably easier by the addition of a Bernoulli Box 20 mg removeable cartridge disk drive to the ERDAS PC environment. The cartridges are affordable enough that we can devote one per study area when needed. Table 1 summarizes the areas for which TM data have been processed.

b. GIS

As mentioned in the previous progress report, the GIS component of this project is critical for improving the information provided by TM. An important phase of the GIS work is the integration of the PRIME ARC/INFO and ERDAS systems. ESRI and ERDAS have not yet completed the necessary hardware and software development for this integration, although we hope for it to take place soon. We have been successful, however, in downloading ARC/INFO polygon files to ERDAS using POLYGRID (polygon to grid cell conversion in ARC/INFO) and CSVF (ARC/INFO to ERDAS grid format conversion in ELAS) software.

This conversion step has allowed us to combine the Illinois GIS data for Jackson and Pope Counties with the TM data. GIS vegetation data are used to mask out non-forest spectral values from consideration in

statistical anlysis. Soils information is used to stratify forested areas by soil suitability for forest production. In addition, site specific forest productivity data are being used with extracted forest spectral values for regression analysis.

c. Elevation Data.

In order to utilize the elevation data with the TM data we must read the data files, reformat them to an ERDAS readable format, and transfer them to the ERDAS workstation. We obtained programs from the Minnesota Land Management Information Center for reading the 18 Illinois quads of DMA data. The programs required modification before they could be used with our tapes. We are currently in the process of reading the data for selected areas from the tapes and producing contour maps of the data. These maps are used to verify the data and give us some measurement of its accuracy. The four DMA quads of areas outside of Illinois are stored in a different format and some programming will be required to read and reformat the data. The DEM data will be read by an ELAS module we are obtaining from John Merola at the University of Utah and reformatted to an ERDAS readable format. We expect by the end of the next reporting period to have developed procedures for converting all of these data to the ERDAS format, and to have integrated these data with other GIS variables.

d. AVHRR

Preliminary testing of existing harware/software compatibility with an AVHRR LAC tape obtained from the University of Missouri-Columbia has been accomplished. Though our test proved no insurmountable problems in reading the data, it was decided to delay further efforts with AVHRR. Inclusion of smaller scale data in the analysis is the final project objective, so work in this area has been postponed in preference of completing other objectives.

2. Correlation Analysis

For correlation analysis, we are combining GIS soils data with GIS vegetation data to compare with TM spectral data. Nonforest polygons are masked out, and indices of soil productivity are correlated with TM spectral data (including vegetation indices) for each vegetation class.

For example, in Jackson County, deciduous woodland productivity indices have been calculated for most soils in the county, and range from 75 board feet/acre/year on rocky outcrop, thin soils, to 575 board feet/acre/year on deep, narrow bottomland soils. In general, the most productive soils fall in the bottomland landscape positions, with slightly less on the upland, thick loess soils, and the least on thin, rocky soils. Some preliminary work has been conducted to make the necessary data combinations, but no correlations have been run to date.

3. Regression Analysis

As mentioned previously, a tape of U.S. Forest Service inventory data has been obtained for Illinois. Preliminary efforts have focused on utilizing these data as ground truth and as the dependent variable in regression analysis. Independent variables include TM spectral channels, ratios, and vegetation indices, GIS soil thickness, soil productivity index, soil texture, slope, vegetation class, and potential solar beam irradiation (PSBI). The final data tape from the USFS has just arrived.

4. Classification Approach

Unsupervised classifications (50 classes) have been produced for Jackson, Pope, Calhoun, and Grundy study areas. The classes are first examined to determine an accurate forest-nonforest classification for masking out nonforest spectral values for statistical analysis. Results from this mask will be compared to those from GIS vegetative mask where available.

In addition, spectral classes which represent forestland are grouped into relative forest productivity classes using prior knowledge of the area

and the presumed effects of slope, aspect, and soil characteristics on productivity. These groupings are validated using ground forest productivity data. In addition, the homogenity of the forest productivity groups will be determined with discriminant analysis to test the spectral separability of productivity. Relative productivity classifications will then be made less subjective by overlay of slope and soils information, for example, and the processes described above will be repeated. Further details of the discriminant analysis methods are given in Report 1, pp 12-13.

5. Signature Comparison

Vegetation has been mapped in the Indian Peaks region of the Colorado Rocky Mountain Front Range under NASA sponsorship during the 1960's and 1970's by the Institute for Arctic and Alpine Research at the University of Colorado. Currently, 1:10,000 scale vegetation maps of the forest - alpine ecotone surrounding the Mountain Research Station at Niwot Ridge, Colorado are being used as ground truth for our application of Thematic Mapper digital data. Vegetation is categorized by structural and floristic indications on these maps. Structural categories include forest, forest - alpine ecotone, and alpine meadows. Floristic indications categorize vegetation by primary forest species.

Both structural and floristic patterns have been digitized and encoded into a GIS layer for the Niwot study area. Thematic Mapper data have also been geographically registered to these maps in order to locate potential training sites. Currently only supervised training techniques have been used to assess the spectral separability of structural and floristic classes in the TM data. In addition, the structural and floristic maps have been combined to produce a composite map defining the intersections of these classes. Additional training sites have been

extracted to evaluate the spectral complexity of structural indications by vegetation species. Preliminary results are not yet available to fully describe the ability of TM data to discriminate these categories.

An unsupervised training device is being developed in order to more fully evaluate the spectral complexity of TM spectral data within the structural and floristic polygons. This procedure is a "guided clustering" algorithm that partitions n-dimensional spectral reflectance pattern into k-classes based on interactive assessment of spectral statistical patterns associated with the map polygons. This analysis is intended to evaluate the internal complexity of TM spectral data for what are considered homogeneous polygons from the structural and floristic maps. This method should provide more "pure" statistical signatures for both structural and floristic classes.

Spatial characteristics of TM data for this study area are also being evaluated for use in discriminating structural and floristic classes. Currently, directional derivatives are being computed to produce composite (horizontal, vertical and diagonal) gradient image maps from the TM data. These gradient maps are being examined to identify boundaries (edges) in the TM scene for spatial comparison with polygon boundaries on the structural and floristic maps. Directional derivatives are also intended to be used for image classification, but no particular procedure has yet been adopted for this analysis.

Part II. APPENDICES

A. PERSONNEL

Dr. Robin Lambert Graham recently joined ORNL and is now working as the ORNL co-investigator on this project. She is part of a team of ORNL scientists involved with landscape and regional studies in the ORNL Environmental Studies Division. Prior to coming to ORNL, she was employed as a research forest ecologist for Weyerhaeuser Company, a major U.S. forest company. As such, she brings to the project considerable experience both in modeling and measuring forest productivity. She received her doctorate in forest ecology in 1981 from Oregon State University under Dr. Jerry Franklin of the USFS Pacific Northwest Forest and Range Experiment Station. Her undergraduate work was done at Dartmouth College where she worked with Dr. William Reiners and did research in the spruce-fir zone of the White Mountains in New Hampshire.

Dr. Jerry Olson has been in Uppsala, Sweden for the past several months but remains active in pursuing contacts and data resources while stationed there. Dr. Paul Risser has moved to the University of New Mexico where he assumed the position of Vice President for Research on July 1. All other personnel are the same as reported earlier.

B. COLLABORATION

Collaborators provide an important aspect for this project since we are dependent on so many sources of data. Some of the main collaborators helpful to us in the past six months are as follows:

1. Mr. Mark Hanson and Mr. Burt Essex from the North Central Forest Experiment Station in St. Paul, MN., have provided us with USFS inventory data for Illinois ground measurement plots which are used for ground truth for Illinois sites.

2. Mr. Les Maki and Mr. Steve Anderson from the Minnesota State Planning Agency, Planning Information Center, provided us EPPL6 GIS grid-based software which has been useful in our data compatibility problem solving efforts.

3. Mr. Richard Durfee and Mr. Jerry Dobson, ORNL Computer Sciences Section, have provided us with digital elevation model files processed through their system. The files include some 7.5 base files and some 1:250,000 scale files.

4. Dr. John Merola, University of Utah Research Institute, provided generous assistance with ELAS modules. He debugged the module needed to convert ARC/INFO data files to ERDAS, via ELAS, and developed modules for handling digital elevation model (DEM) files.

C. FACILITIES AND EQUIPMENT

Some changes have occurred since Report 1. At INHS, the Prime computer has been upgraded by networking the PRIME 750 with a newly acquired PRIME 9955. Combining these machines has increased the processing capabilities by about five times on GIS manipulations of the data. We are still waiting for the ERDAS software to be installed on the PRIME. Other acquisitions helpful to the project at INHS include an AT-compatible Zenith-241 PC (used primarily for statistics, word processing, data entry, and as a terminal to the PRIME), and an Iomega Bernoulli Box which allows rapid swapping of 20 megabyte cartridges. At both INHS and the UI Geography Department, a new version of ERDAS software was installed which increases image processing capabilities.

D. RESEARCH SITE BACKGROUND.

1. Great Smoky Mountain National Park, TN and SC

The Great Smoky National Mountain Park was established in 1934 and encompases 209,000 hectares along the Tennessee and North Carolina borders.

a. Geography

The park consists of a complex set of ridges and valleys generally oriented in a north-south direction. Elevation ranges from 270m to 2024m. Only 20% of the landscape is pristine. The other 80% has experienced direct human disturbance in the form of logging and farming, although these activities ceased with park establishment. Human-set fires were frequent in the western half of the park prior to 1930 and the chestnut blight (1920-1940) removed a major forest dominant across much of the park.

b. Climate

The climate in the park is strongly influenced by the abrubt changes in elevation and the complex topography of the Smokies. Temperatures in February range from monthly mean of 4.4 C at 445m to -1.8 C at 1919m. July temperatures at these same elevations average 22.1 C and 13.6 C respectively (Fig. 1).

Precipitation increases with elevation from 151cm at 445m to 230cm at 1919m. October is the driest month while February and March are the wettest. Maximum vapor pressure deficits occur in spring, especially at the lower elevations. (Fig. 2).

c. Vegetation

Complex topography and extensive disturbance have created a complex, finely patterned mosaic of vegetation communities. Successional forests cover much of the park. Cove forests containing such species as Fagus grandiflora, Tilia heterophylla, Liriodendron tulipifera and Aesculus octandra are found in sheltered positions at mid

elevations. On exposed low to middle elevation slopes, Quercus prinus, Pinus pugens, Nyssa sylvatica, Oxydendron arboreum, and Acer rubrum are found. On the highest slopes, pariculary in the northeastern half of the park spruce-fir forests dominate (Pincea rubra and Tsuga canadensis). In recent years the balsam wooly aphid has significantly impacted these high elevation forests.

d. Databases

The vegetation of the park has been extensively studied, although only one detailed vegetation map exists for the entire park and it was created in the mid 1930's. Soils data, like much of the vegetation data, tend to be study specific and consequently spatially patchy. We have, however, been able to locate and acquire a uniform productivity dataset covering 127 forest plots scattered in the Cades Cove and Thunderhead USGS quadrangles of the park. This data set collected for a University of Tennessee thesis contains forest productivity data, in addition to GIS data such as slope, aspect, forest type, elevation and soil qualities. Additional forest productivity data for 20 plots in the spruce-fir zone may become available to us in early 1987. We hope to also remeasure 18 monumented forest growth plots established by Dr. J. Olson and Mr. R. Becking in 1976 and 1977. These plots will further enhance our database.

There is currently an ORNL proposal to NSF which if funded would collate data from all the historic and ongoing studies in the park. Our project will dovetail nicely with this work.

E. RELATED MEETINGS, SEMINARS AND PUBLICATIONS SINCE FEB. 1986.

Binkley, D., and R. L. Graham. 1981. Biomass, production and nutrient cycling of mosses in an old-growth Douglas-fir forest. Ecology 62:1387-1389.

Frank, T. D. 1985. Remote sensing land quality changes in arid and semi-arid environments: a review. Annals of Arid Zone 24(3).

Frank, T. D. 1986. Classifying alpine tundra with color IR photography and topoclimate. Colloquia at the University of Kansas, Lawrence.

Graham, R. L., P. Farnum, R. Timmis, and G. Ritchie. 1985. Using modeling as a tool to increase forest productivity and value. In: Forest Potentials--Productivity and Value, Proceedings of the 4th Weyerhaueser Science Symposium. August 20-24, 1984. Tacoma, Washington. Weyerhaueser Science Symposium 4:101-130.

Graham, R. L., R. R. Fox, and R. M. Dougherty. 1986. The Potential role of systems models in stress management. Chapter 8. In: Proceedings of the SAF Physiology Symposium, July 31, 1985. Fort Collins, CO, Marinuf-Nijhoff (in press).

Graham, R. L. and K. Cromack, Jr. 1982. Mass, nutrient content, and decay rate of dead boles in rainforests of Olympic National Park. Canadian Journal of Forestry Research 12:511-521.

Graham, R. L. 1985. The use of modeling in forestry. Lecture presented to Silviculture Institute at the University of Washington, Seattle, WA.

Iverson, L. R. 1986. Presented paper entitled "Analyzing long-term vegetation changes utilizing geographic information system and remotely sensed data" at the XXVI Committee on Space Research Meeting in Toulouse, France. July 1986.

Iverson, L. R. 1986. Visited the North Central Experiment Station, St. Paul, Minnesota. July 1986

Iverson, L. R. and E. A. Cook. 1986. Presented poster entitled, "Ecological applications of the Illinois Geographic Information System, A case study of Jackson County, Illinois " at the annual meeting of the Board of Natural Resources in Champaign, Illinois. May 1986.

Iverson, L. R. 1986. Attended monthly meetings of the Illinois Commission on Forest Development (served as Chairman of the Forest Resources Analysis Committee), Springfield, Illinois. January- July, 1986.

Iverson, L. R. 1986. Presented seminar at the University of Illinois Landscape Architecture Department entitled "Landscape disturbances in Illinois: Studies of adverse human impacts and possible mitigation". April 1986.

Lambert, R. L., G. E. Lang, and W. A. Reiners. 1980. Loss of mass and chemical change in decaying boles of a subalpine balsam fir forest. Ecology 61:1460-1473.

Lambert, R. L., and W. A. Reiners. 1979. Nitrogen-fixing moss associations in the subalpine zone of the White Mountains, New Hampshire. Arctic and Alpine Research 11:325-333.

Olson, J. S. 1986. Visiting scientist ar two universities in Uppsala, Sweden. May - present, 1986.

Treworgy, C. G. and M. H. Bargh, 1986. Geographic Information Systems:

A Computer Technology for the Coal Industry. In Use of Computers in the Coal Industry. p. 99-108. A. A. Balkema, Rotterdam, Netherlands.

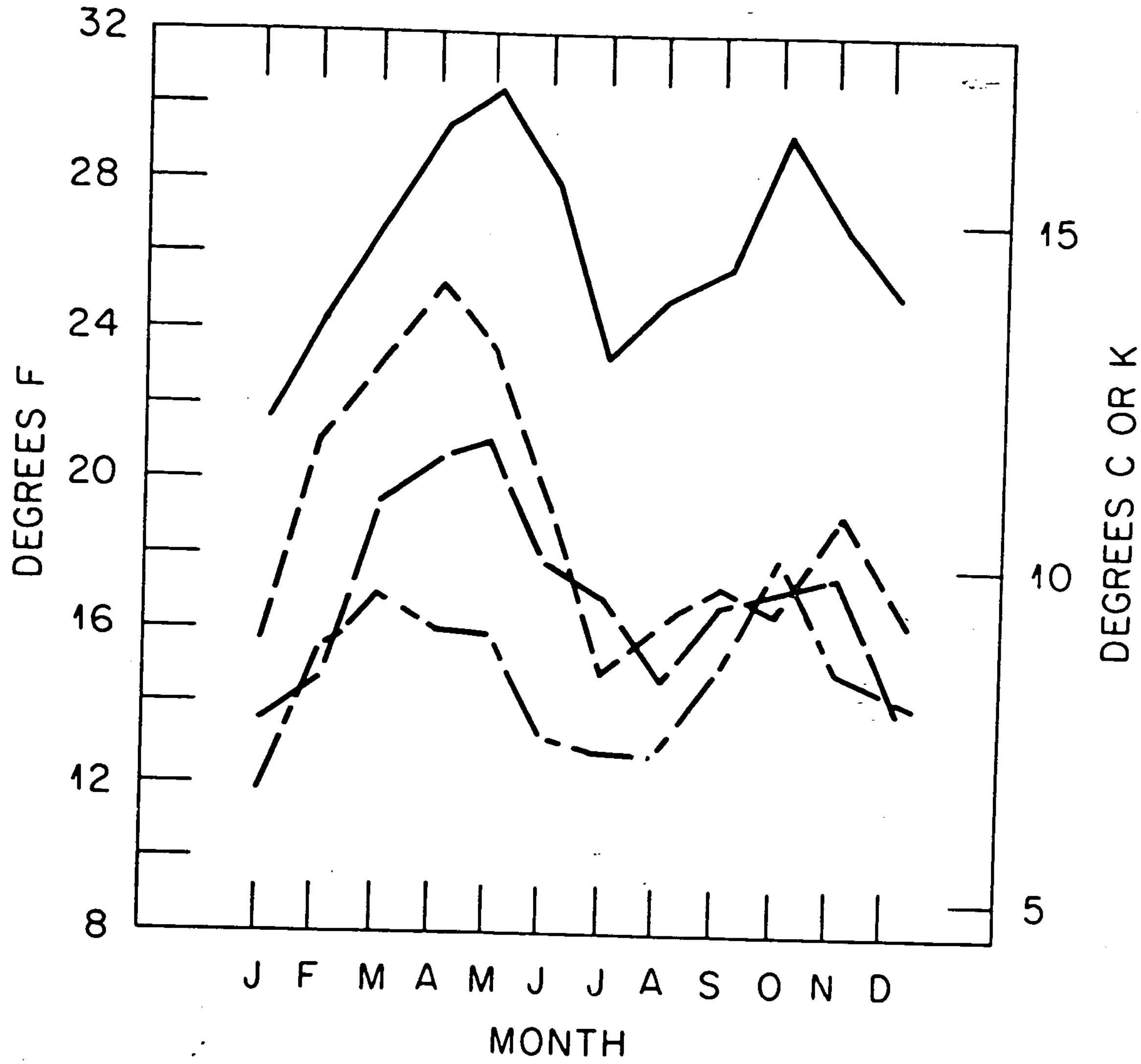

Fig. 1. Monthly mean temperature range for 1947-1950 at the 1460 ft. (———), 3850 ft. (-----), 5000 ft. (— —), and 6300 ft. (—••—) stations (Stephens 1969).

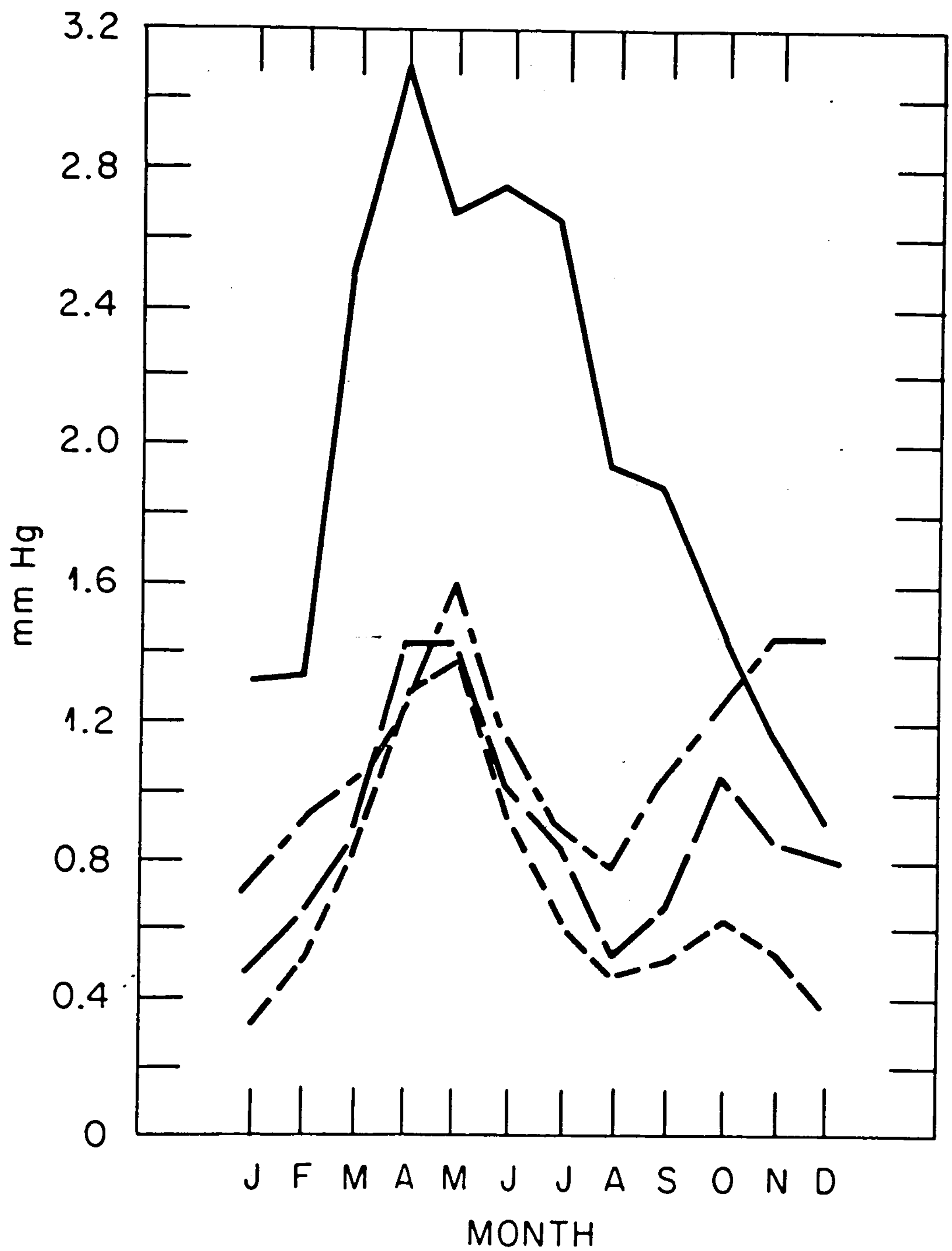

Fig. 2. Monthly mean vapor pressure deficit (mm Hg) at the 1460 ft. (———), 3850 ft. (-----), 5000 ft. (— —), and 6300 ft. (—•—) stations for 1947-1950 (Stephens 1969).

Table 1. PROJECT ACTIVITIES BY STUDY AREAS

Study Areas	Establish Data Archiving and Project Record Keeping System	Assess TM Data Availability and Quality	Assess Ancillary Data Availability and Format	Establish Regional Contacts Per Study	Literature Review	Extract Study Area TM Data	Export TM Data to ERDAS	Statistically Analyze TM Data	Export Ancillary Data to ERDAS	GIS and Statistical Analysis of TM/Ancillary Data	Results
Mt. LeConte and Cades Cove	1	1	1	1	1	2	2		2	3	
Oak Ridge	1	1	2	1	2						
Whiteface and Huntington	1	1	1	2	2	2			2		
Jackson	1	1	1	1	2	1	1	2	2	2	2
Pope	1	1	1	1	2	1	1	2	2	2	2
Calhoun	1	1	2	2	2	1	1	2	2		
Lake	1	1	2	2	2	1	1	2			
Grundy	1	1	2	2	2	1	1				
Outagamie	1	1	2			1	1				
Boulder	1	1	1	1	1	1	1	2	1	2	2
Pawnee	1	1	2	2	2						
Maine	1	1	2								
Custer	1	1	2	2	2						
Minnesota	1	1	2	2	2						
Emery	1	1	2	2	2	1	1	2			
Konza	1	1	2	2	2	1	1				
Tall Timber	1	1	2	2	2						
Quebec	1	1	2	2	2						
Sierra Nevada	1	1	2	3	2						
Santa Barbara	1	1	2	2							

Table 2. ACQUISITION OF ANCILLARY DATA BY STUDY AREAS

Study Areas	Topographic Maps	AVHRR	Soils	DMA Elevation	DEM Elevation	Vegetation Maps	Forestry Ground Data
Mt. LeConte and Cades Cove	3	4	1A	4	4	1A	4
Oak Ridge	1A	4	0	1A	1A	1B	0
Whiteface and Huntington	3	1A	2	4	0	3	2
Jackson	3	1A	4	4	1B	4	4
Pope	3	4	4	4	1B	4	4
Calhoun	3	1A	1B	4	1B	4	4
Lake	3	4	4	4	1B	4	4
Grundy	3	4	4	4	1A	4	4
Outagamie	3	4	4	1A	1B	1A	2
Boulder	3	1A	3	1A	1A	3	3
Pawnee	3	1A		1A	0	3	0
Maine	3	1A	3	1A	1B	1A	0
Custer	3	1A	3	4	0	1A	0
Minnesota	3	1A	0	1A	1B	1A	0
Emery	3	1A	3	1A	0	1B	0
Konza	3	1A	4	1A	1A	3	2
Tall Timber	3	4	4	1A	1B	1A	3
Quebec	3	1A	0	1A	0	0	0
Sierra Nevada	3	1A	3	4	1A	1A	0
Santa Barbara	3	1A	3	1A	1A	1A	0
Natchez	3	1A	3	1A	1B	4	0
Oregon	3	1A	0	1A	1B	1A	0
Coweeta	3	4		4	0	1A	3
Okefenokee	3	4	1B	1A	1B	1A	0
Oconee	3	4	3	1A	1B	1A	1A
Comanche	3	1A	4	1A	1B	1B	0
Puerto Rico	0	1A	5	5	5	5	5

0 = not yet pursued; 1A = available; 1B = unavailable; 2 = ordered; 3 = inhouse, non-digital format; 4 = inhouse, digital format; 5 = will not be used